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## THE ROENTGEN DIAGNOSIS OF GALL-STONES BY IMPROVED METHODS.

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UP to about three years ago gall-stones were detected by the Roentgen method of examination in such a small percentage of the suspected cases that most Roentgenologists, including ourselves, did not recommend the examination, and made it only when urged to do so. Several of us found, however, that gall-stones containing calcium could be detected much more frequently than we had supposed, and this discovery stimulated the search for them. As yet, only a few Roentgenologists had published reports on gall-stones.<sup>1</sup> In 1913, however, four observers reported almost simultaneously that gall-stones could be detected Roentgenographically in from 50 to 70% of the cases in which they were really present.<sup>2</sup> This estimate of the percentage of gall-stones was obtained in two ways. Case reported detecting 50 in 1000 cases. Cole reported detecting 20 in 499 cases. As these observations were made during about the same period, and each reported independently of the other, it was significant that the percentage was almost identical in the two reports.

It is a well recognized fact that gall-stones are found in 10% of all adult cases submitted to post-mortem examination, and as we were able to detect them in 5% of the cases in a routine gastro-intestinal examination, we therefore concluded that we could find them in about one-half of the cases where they were present.

Pfahler estimated that he could detect gall-stones in 74% of the cases, which according to him, was 24% more than could be obtained by other Roentgenologists.

His percentage was based on 29 cases operated on for gall-stones, in 27 of which stones were found. He had reported findings in twenty of these, but had been unable to detect them in seven where they existed, and in two cases he had reported probable stones wherein no stones were found,—a record of nine erroneous diagnoses.

Therefore, what Pfahler really reported was 31% of erroneous diagnosis, rather than a percentage of accuracy.

When stones are detected by Roentgen methods, an operation for their removal is almost universally assured, and unless there are errors in interpretation, the stones are found. But if no stones are found through these methods, the operation is not so likely to be performed, and of this case one has no knowledge of whether or not stones are present. Therefore such a method of estimating the percentage is not accurate.

A series of cases might be examined, however, in the manner employed by Brewer and Cole,<sup>3</sup> in gastro-duodenal lesion, viz: If by using all other methods combined, the surgeon determines that gall-stones are present, he will operate for them regardless of the Roentgen findings. The Roentgenologist makes his examination, making



a definite negative or positive diagnosis exclusively on the Roentgen findings and the operation, and then compares the findings. This method of estimating would give one an accurate percentage of the cases that are detectable by Roentgen rays.

Among the Roentgen plates exhibited at the last meeting of the Roentgen Ray Society, George showed 15 cases of gall-stones, each presenting faint shadows of the calculi. Some of these were so indistinct that even a keen observer would have failed to detect them, and Cole was even doubtful of the significance of the shadows in some cases, although in a previous communication,<sup>4</sup> he himself had described and attempted to illustrate an article on gall-stones with two or three similar Roentgen plates.

Since we have paid close attention to the gall-bladder region in the routine gastro-intestinal examinations, studying the cases observed by this method, and reviewing previous Roentgen plates of the gall-bladder, much valuable information has been obtained which has led us to believe that we can detect stones at least twice as frequently as before. After having considered that we detected them in 50% of the cases, it would now appear that we can show them in all cases where they are present.

One of the writers (Cole) now believes that far more than 10% of the cases presenting themselves for a Roentgen examination of the stomach and the gall-bladder region, have gall-stones, and therefore that one is not justified in estimating the percentage of detectable gall-stones in the manner previously employed by him and Case. Having once made this error, Cole hesitates to base the percentage of detectable gall-stones on anything less than such a test as that

employed by Brewer and Cole on gastro-duodenal lesions. But we believe this method is sufficiently accurate to justify a careful Roentgen examination of every patient over forty who complains of gall-bladder or gastric symptoms.

A positive Roentgenologic diagnosis can be made in such a large number of the cases where gall-stones are present, that the negative diagnosis has become far more important than it was previously considered to be.

The technic is not radically different from that employed for soft tissue detail in any other part of the body; but it requires conscientious attention to the most minute points, and one must not be satisfied with the Roentgen plates, unless detail is shown to the greatest possible degree. Roentgen plates obtained by improved technic, show extraordinary detail; in two cases even the pelvis of the kidney, the blood-vessels going to and from it, and the upper part of the ureter were remarkably distinct.

Our opinions differ as to the advisability of catharsis prior to the examination. One of the writers (George) considers that the gas usually resulting from a cathartic is a more disturbing factor in the interpretation of the Roentgen plate than the fecal content of the colon. This, he thinks, may aid in determining the location of the gall-bladder. His colleague (Cole) on the other hand, thinks that a thorough catharsis and total abstinence from food for twelve hours prior to the examination is very essential; also that the gas in the colon often serves to accentuate the calculi, and in a previous communication,<sup>5</sup> he has advocated the artificial injection of air into the colon in some doubtful cases as a means by which shadows of gall-stones may be accentuated or identified.

The use of the Coolidge tube enables one to obtain an accuracy of penetration which is unattainable with a standard tube. Roentgen plates showing brilliant bone detail with considerable density of the soft parts are not desirable for the diagnosis of gall-stones. Soft "monotonic" Roentgen plates obtained with the Coolidge tube, are deprecated by some critics because marked contrast in the bony structure is lacking; but they show remarkable gradations in the soft tissue—a result for which one strives when in search of gall-stones.

Minor condemned fine Roentgen plates of the lungs as compared with the fluoroscopic image, because they showed so much detail in the soft parts as to make them difficult to interpret. It is the interpretation of these very details that increases the accuracy of diagnosis, whether it be the chest or gall-bladder that is under consideration.

One of the co-authors herein (Cole) strives to obtain this detail by using a small focal point tube of a penetration just sufficient to cast an image on the screen beneath the patient, and makes the exposure long enough to obtain the desired density of the Roentgen plates, whilst his colleague, (George), considers speed an important factor, and uses a fairly large focal point with varying penetration, making the exposure so short that it practically eliminates the effect of the involuntary motions of the body, particularly gastric and intestinal peristalsis and pulsations of the blood vessels.

The necessity of using an extremely small cone, showing only a limited area in each Roentgen plate is strongly emphasized. The length of the cone is not an essential factor. By means of such a cone secondary rays are generated in



the patient to a much less degree, and the fogging effect being proportionately diminished it is then possible to show distinctly a calculus that would be quite invisible if a large or moderate sized blend were used. The cone may be pointed obliquely downward, so that the axis of the rays is parallel with the under surface of the liver. When this is done, the under surface of the liver appears as a clear cut and well defined line; and the gall-bladder, if normal, can usually be detected, or the relation of the patient to the tube may be altered by a slight rolling from side to side. Sometimes, particularly when the gall-bladder is high, a lateral position will show the gall-stones against the background of the liver.

It matters very little whether screened or unscreened plates are used. Some plates may be made with screens, and some without them. The unscreened plates should be exposed face to face, and slightly undertimed, with a view to matching up the shadows thereon after development. Double screened plates also may be made in a special holder, constructed to carry screens of different rapidity. Two plates and two screens of different speed are used in the same holder. The plates are placed back to back. The under one face down, lies against a fast screen, whilst the upper one lies face upward against a relatively slow and thin screen. A very short or even undertimed exposure is made, and after development the plates are superimposed and matched together, whereupon by transmitted light one gets the plastic effect up to a certain point. This method eliminates screen and plate defects to a great extent.

Roentgen stereoscopy adds very materially in the interpretation of the Roentgen plates. Four exposures may be made, preferably with each



exposure on the two plates face to face, giving a slight lateral shift to the tube between the first and second exposures. Then move the tube down about two inches and make two more exposures, shifting the tube once more in the lateral direction between the third and fourth. In this manner, one can stereoscope the various exposures with each other, that is to say, 1-2 and 3-4 stereoscoped with each other laterally; and 1-3 and 2-4 stereoscoped with each other vertically.

Comparison from behind avails little; but small areas may be brought close to the plate for detailed examination, by the use of a circular plate-holder about the size of the end of a small compression blend. This holder, with or without a screen, may be pushed up under the edge of the rib, thereby materially diminishing the thickness of that part of the abdomen.

The entire region from the eleventh rib to the crest of the ileum or even lower, should be included in the examination. As repeated exposures are required, and as some of the plates are not screened, the total exposure is considerable, and a filter should always be used to prevent dermatitis. If after careful study of at least fifteen or twenty Roentgen plates of the gall-bladder, no evidence of the calculi is found, the patient should be submitted to an examination of the stomach, duodenum, and colon, in a search for adhesions from cholecystitis without stones, or for the purpose of differentiating this condition from post-pyloric ulcer and appendicitis with reflex gastric symptoms.

Even when there is direct evidence of the stone, this additional information is of great value in determining whether or not there is a concomitant lesion, whether or not surgery is indicated and how difficult the operation may be.

Although the technic herein described greatly facilitates the interpretation of the Roentgen plates, gall-stones may be detected in the ordinary Roentgen plate, in a large percentage of cases if one is familiar with their Roentgenographic appearance.

Of late, a re-examination has been made of those Roentgen plates taken during the last four or five years in which direct evidence of gall-stones was insufficient or undetected, but which showed enough evidence of adhesions from the accompanying cholecystitis to justify surgical procedure. In the re-examination, our increased knowledge of the Roentgenologic appearance of soft gall-stones has enabled us to detect direct evidence of the calculus on the Roentgen plate, in a large number of cases where calculus was found at operation.

The same results have been obtained from a re-study of those cases where the gall-bladder only was examined, and a negative diagnosis was made. The gall-stones found at operation in these patients can now be identified in the original Roentgen plates. The evidence was there before, but we were then unable to recognize it.

Of all the aids to be suggested for detecting calculi, the method of matching together the shadows by superimposing one Roentgen plate over another, as described in a previous communication,<sup>6</sup> is probably the most important. By far the best illumination can be obtained by holding the plate obliquely at an arm's length against the northern sky. A concave lens or better still a pair of opera glasses used in the reverse direction, will accentuate contrasts. For examining a small area, a magnifying glass may be helpful, especially in identifying the faceted side of small calculi.

A lantern slide made of superimposed Roentgen plates, will sometimes accentuate the contrast and bring out details not observed in the original plates. Thus very faint shadows may sometimes be shown well enough for lantern slide demonstration or reproduction; whereas others cannot be demonstrated or reproduced for publication, because the shadows concentrated on the slides are diffused by enlargement.

Identification of the gall-bladder aids materially in the detection of calculi, and is a detail which one should always try to obtain. It can be detected in nearly every case where it exists, normal in size or dilated. The gall-bladder may be found anywhere from the region of the eleventh rib to the fifth lumbar vertebra. In one case, it was located as far down as the sacrum. As a rule, it will be seen below the lower border of the liver. If, after taking a number of Roentgen plates, the gall-bladder is not found in the normal position, it can sometimes be located when a subsequent bismuth examination is made, by noting the position of the transverse colon.

Roentgenographically, gall-stones are divided into two definite groups: (1) Stones which contain considerable calcium, and (2) Cholesterine stones which contain no calcium, or only a trace of it. Gall-stones containing a large proportion of calcium can be shown without much difficulty and are sometimes so dense as to be mistaken for renal calculi.

The dense calcareous gall-stones are a type of calculi infrequently found; this perhaps explains why the study of gall-stones has made little advance since they were first observed. By far the greater number of gall-stones consist of cholesterine nucleus, with a calcareous coating,



or *vice versa*. When the peripheral concretions are thin, which is true in about 50% of the cases, the stones are difficult to detect. With increasing density of the coating, the ring-like appearance is proportionally more marked and relatively easier to discover; but it is probably safe to say that the absolutely pure cholesterine stone is a rare entity<sup>7</sup>.

Unless unusual care is used in making and interpreting Roentgen plates, cholesterine stones containing only a trace of calcium will be entirely overlooked in the future, just as they have escaped observation in the past. It is not the shadow producing quality of the stone as a whole that concerns us in this class of case, but rather the shadow cast by the long diameter of the periphery of the stone. Whether the stone be faceted, spherical or a combination of both, in some particular diameter there will be sufficient density to cast a peripheral shadow. This explains in part why a single Roentgen plate of a series will often reveal a perfectly characteristic gall-stone, whereas all previous plates of the same region show only questionable shadows. If each individual stone in a mass of small stones does not cast a well-defined shadow, the shadow of the entire mass will often give the clue.

The interpretation of suggestive shadows in the region of the gall-bladder is fraught with difficulties, similar to those experienced when positive diagnosis of kidney stones was first attempted. The present accuracy in diagnosing renal stones is the result of experience gained through numerous errors. Some of the disturbing factors in the gall-bladder region, such as intestinal contents, calcified mesenteric glands, costo-chondral ossification, and stones in

the kidney and liver, have been enumerated in previous articles.<sup>8</sup> Recent experience has added to our knowledge of possible pitfalls. Food in the cap is a particularly confusing finding, because its density corresponds to the faint shadow of a stone, and its size and position add to the illusion. Upon minute examination, however, it will be found that the shadow of food in the cap lacks the ring-like circumference of the cholesterine stone with a calcareous shell; neither has it the homogeneous character of the calcium stone, but is rather mottled in appearance. Moreover, it is usually possible to completely identify the shadow by tracing the outlines of the adjoining pars pylorica. Where the shadows are obscure several Roentgen plates matched together, will increase the density. A disturbing element of the same character is food contained in a single haustrum of the colon at the hepatic flexure. Being broad at one end and tapering to a fine point at the other end, it resembles an almond-shaped calculus. Abstinence from food eliminates results from this error.

Another interesting finding, and one which is visible only to the eye trained to pick up the slightest variation in density, is the presence of little rings, often no larger than a good sized pinhead, sometimes found in groups, sometimes isolated, in varying shapes of round, oval, or even quite irregular form. It is quite possible that these infinitesimal findings are the walls of bloodvessels seen in cross section.

It is a mistake to study Roentgen plates when they are wet, not only because reflected light cannot be avoided, but also because there is risk of damaging the plate.

A careful study of the clinical history of cases in which gall-stones are definitely shown by

Roentgen methods, reveals the futility of expecting the classical gall-bladder symptoms to agree with the Roentgen diagnosis.

Before the advent of the x-ray, renal colic and renal calculi were considered almost synonymous terms. But surgical procedure for renal colic in cases where no calculus was shown on the Roentgen plate, eventually proved that only about one fourth of the cases having typical attacks of renal colic had a calculus of sufficient size to be found by surgical exploration. On the other hand, only about one fourth of the cases in which kidney stones were definitely demonstrated by Roentgen methods, had anything simulating renal colic.

Our present experience indicates that the same observation will hold true in the gall-bladder region; that only when a gall-stone passes or engages does it cause the typical gall-stone colic, and this is relatively rare compared with the frequency of gall-stones.

The clinical indications of cholecystitis compare with those of pyelitis, except that one does not detect the presence of pus in the stools as readily as he detects it in the urine. Some of the cases of gall-stones give practically no characteristic symptoms of gall-stones, but are associated with obscure gastric or neurotic symptoms.

Therefore, any case presenting gastro-intestinal symptoms with absence of Roentgen evidence of an organic lesion of the stomach or intestines, should be submitted to a careful Roentgen examination of the gall-bladder. This is particularly true if, as Deaver suggests, the patient is "fair, fat and forty, and belches gas."

It is much easier to detect the stone in this class of case, than in thin, wiry, poorly nour-



ished people who have no fat to outline the gall-bladder, and whose muscle is nearly as dense as bone. In persons under twenty-five, the peripheral coating of the stone is not usually dense, and the stone is so soft that it does not show even a dim peripheral ring or edge. Post operative cases with extensive adhesions, carcinoma of the liver or gall-bladder, and ascites also render negative diagnosis exceedingly difficult if not impossible.

Diagnostic accuracy is directly in proportion to the care exercised in making the examination, and one's experience in detecting and interpreting the findings. Statistics are of little value until thousands of cases have been observed by methods as careful and detailed as those described above. By that time the value of the method will be generally acknowledged, and statistics will not count for any more than they do now in cases of renal calculi or fractures.

The Roentgen method of diagnosing gall-stones has become so accurate that if there is no direct Roentgen evidence of gall-stones, or indirect evidence of adhesions involving the stomach, cap, duodenum, or colon, as a result of cholecystitis, the surgeon should have a preponderance of clinical evidence as a warrant in operating for gall-stones.

#### RESUMÉ.

1. Until within three or four years, gall stones were rarely detected by Roentgen rays.

2. During the last few years several Roentgenologists, including ourselves, consider that they have detected gall-stones in about 50% of the cases examined. This was estimated in different ways by different men.

3. Experience has shown that gall-stones may be detected about twice as frequently as formerly by: (a) A special technic for making the Roentgen plates; (b) A minutely careful study of the Roentgen plates by various methods; (c) A thorough intimacy with the Roentgenographic appearance of gall-stones.

4. By applying the new method of interpretation, gall-stones have been detected on many Roentgen plates made by the old technic, and formerly diagnosed as negative.

5. By means of the special technic for making and interpreting Roentgen plates, a positive diagnosis may be made in so many cases, that the negative diagnosis has become of considerable significance.

6. Much care and study will be necessary to properly interpret the additional detail which can be obtained by the special technic, and undoubtedly some erroneous diagnoses will be made. (Cole has made two such erroneous diagnoses in the last month, and has thereby learned to differentiate the food in the cap and the feces in the haustra of the colon from evidence of calculi.)

7. If there is no direct Roentgen evidence of gall-stones, the stomach, cap, duodenum and colon should be examined for adhesions from an accompanying cholecystitis.

8. If there is no direct or indirect Roentgen evidence of gall-stones, the clinical history should be more characteristic than usual before one resorts to surgical procedure.

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